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05JUN02 E723134-5 D02917

P01/7700 0.00-0212699.3

Request for grant of a patent

The Patent Office
Cardiff Road
Newport
South Wales NP10 8QQ

1. Your reference

1878801/AM

2. Patent Application Number

0212699.3 | 31 MAY 2002

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Synaptics (UK) Limited
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Patents ADP number *(if known)* 7866809003

If the applicant is a corporate body, give the country/state of its incorporation

Country: **ENGLAND**
State:

4. Title of the invention

SENSOR BOARD WITH FEET

5. Name of agent **Beresford & Co**

"Address for Service" in the United Kingdom to which all correspondence should be sent

2/5 Warwick Court
High Holborn
London WC1R 5DH

Patents ADP number

6. Priority details

Country	Priority application number	Date of filing

7. If this application is divided or otherwise derived from an earlier UK application give details

Number of earlier application — Date of filing

8. Is a statement of inventorship and or right to grant of a patent required in support of this request?

YES

9. Enter the number of sheets for any of the following items you are filing with this form.

Continuation sheets of this form	
Description	4
Claim(s)	
Abstract	
Drawing(s)	13 α 13

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents form 7/77)*	**1 + 1 COPY**
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for Substantive Examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application

Signature Beresford & Co
BERESFORD & Co — Date 31 May 2002

12. Name and daytime telephone number of person to contact in the United Kingdom — ALAN JOHN SHAW MACDOUGALL

Tel: 020 7831 2290

Sensor Board with Feet

1 FILING INFORMATION

This document references the following other patent filings, the contents of which are incorporated by reference herein:

Number	Assignee	Reference
GB 95/01095	Synaptics	Spiral I
GB 98/01759	Synaptics	Spiral 3D
WO 01/29759	Synaptics	Excitation Drive Technique
WO 00/33244	Synaptics	PDA Spiral System
GB0112332.2	Synaptics	New application 21 May 2001
GB0205116.7	Synaptics	Position Sensor
Filed GB 28 May 2002	Synaptics	Two Dimensional Conductor Pattern for Inductive Position Sensor

2 INTRODUCTION

This patent is for inductive position sensing of an object above a two-dimensional sensor board, for example for pen input to computing devices. It has particular advantages for pen input to communications devices, particularly small, low-cost ones, for example personal digital assistants (PDAs), mobile telephones, Internet browsers and combinations of these.

A simplified sensing coil layout of a prior art system is illustrated in figure 1. Individual coils are illustrated in figures 2 to 5. There are four sensing coils whose coupling factor to a moving coil vary with sine and cosine dependence on either the x or y position of the moving coil:

$$K\sin X = Kx\cdot\sin\left[\frac{2\cdot\pi\cdot x}{Lx}\right]$$

$$K\cos X = Kx\cdot\cos\left[\frac{2\cdot\pi\cdot x}{Lx}\right]$$

$$K\sin Y = Ky\cdot\sin\left[\frac{2\cdot\pi\cdot y}{Ly}\right]$$

$$K\cos Y = Ky\cdot\cos\left[\frac{2\cdot\pi\cdot y}{Ly}\right]$$

An electronic sensing system, for example the one illustrated in WO 00/33244, makes an estimate of the relative magnitude and signs of KsinX, KcosX, KsinY and KcosY and uses these values to determine X and Y position:

$$X = Lx\cdot a\tan 2[K\cos X, K\sin X]$$
$$Y = Ly\cdot a\tan 2[K\cos Y, K\sin Y]$$

In a practical system, each sensor coil typically has several turns in order to improve accuracy and increase the EMFs induced by an energised moving coil, thus improving signal to noise ratio and hence power efficiency. However, when a resonator is near the perimeter of the sensor board its coupling to the sensor coils is reduced significantly relative to central positions.

A consequence of multiple turns for each coil is to increase the coupling to any nearby inductive emitter, for example a display and its drivers. This increases the noise level.

An increase in the number of turns can therefore increase signal level across the sensor board, but also results in increased noise. An objective of the invention described in this document is to improve the worst case signal to noise ratio.

A further objective of the new invention is to improve accuracy near the sensor board perimeter and especially the corners.

3 DESCRIPTION

Figures 6, 7, 8 and 9 show the conductor positions of the cos X, sin X, cos Y sin Y sensing coils respectively. For each plot, greyed conductors are part of each coil but are not built on the same PCB layer as the bold conductors. Greyed vias share the same layer as the conductors shown in bold but connect other coils.

Figures 10, 11, 12 and 13 illustrate the four PCB layers of the sensor board which implements the coil patterns of figures 6 to 9. In addition there are two turns of the excitation coil on each of the four layers.

Signal levels have been boosted at the perimeter of the sensor board and especially the corners. In the case of the cos X coil illustrated in figure 6 two different approaches have yielded this improvement.

Firstly, the conductors comprising the leftmost and rightmost sections of the coil bulge inwards at the top and bottom, so that the x extent of the enclosed area is greatest at the top and bottom.

Secondly, the conductors comprising the centre section make additional turns around the top and bottom of the sensor board.

Both of these modifications to the prior art increase the mutual inductance between sensor coils and moving resonator near the sensor board perimeter and especially the sensor board corners, and minimum signal EMFs are therefore increased. Furthermore, since the areas with increased coupling are restricted to the perimeter of the sensor board, the coupling to unwanted noise sources is not increased unnecessarily.

Similar approaches are adopted for the sin X, cos Y and sin Y coils illustrated in figures 7, 8 and 9 respectively.

In the case of the central portion of the cos Y coil illustrated in figure 8, the additional turns at the left and right hand edges are connected across the middle of the board. The conductors forming this connection are close together in the y direction so that the increase in coupling is minimised except near the left and right hand edges. In addition there is one loop of conductor both above and below this central connection region wound in the opposite sense, which is wound in the opposite direction to the main inner loop and serves to reduce coupling except at the left and right hand edges. This reduction in coupling in

the central region can alternatively be viewed as an increase in relative coupling near the sensor board's perimeter.

In figure 1, a resonator in the central region couples to portions of the x sensing coils both above and below the resonator in the y direction. However a resonator near the top edge of the sensor board couples only to the portion of the x sensing coils below. This lack of symmetry causes poor accuracy. The increased coupling near the sensor board perimeter achieved with the new sensor board design approach partially compensates for the missing coupling to coils above the resonator and yields an accuracy improvement.

4 ALTERNATIVE EMBODIMENTS

The approaches outlined in this document are equally applicable to GB 98/01759.

The approaches outlined in this document are equally applicable to sensor coil designs implemented on a 2 layer PCB, or PCBs with other numbers of layers. They are also appropriate for wire wound devices.

Although the description above was for pen input to mobile devices, the approach is equally applicable to other applications for position sensing in at least 2 dimensions.

The moving element may be a resonator as described above, but may also be a moving powered coil or a flux concentrator.

Figure 1

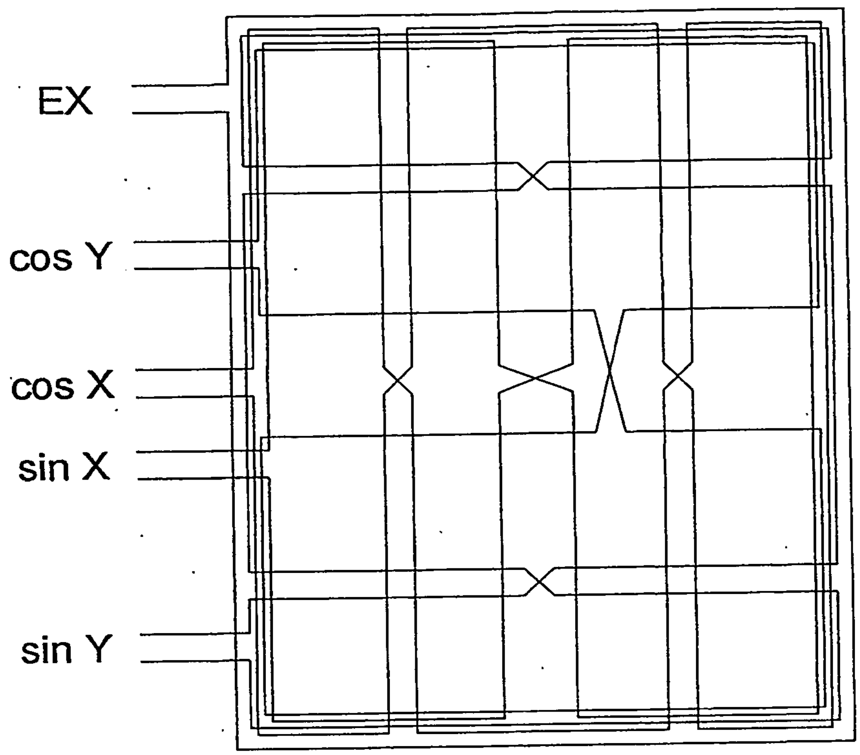

Figure 2

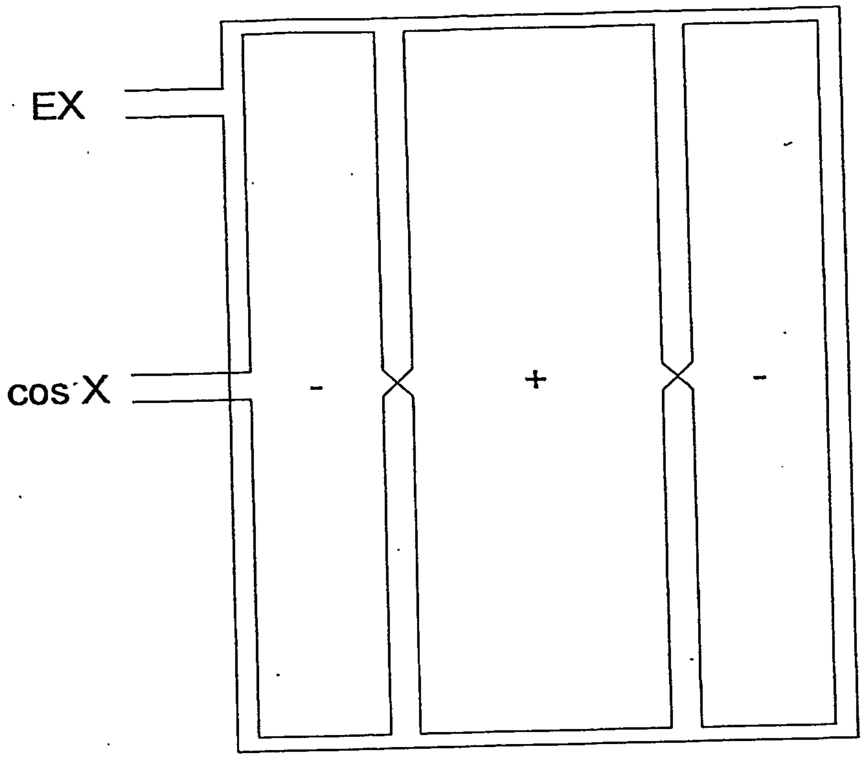

Figure 3

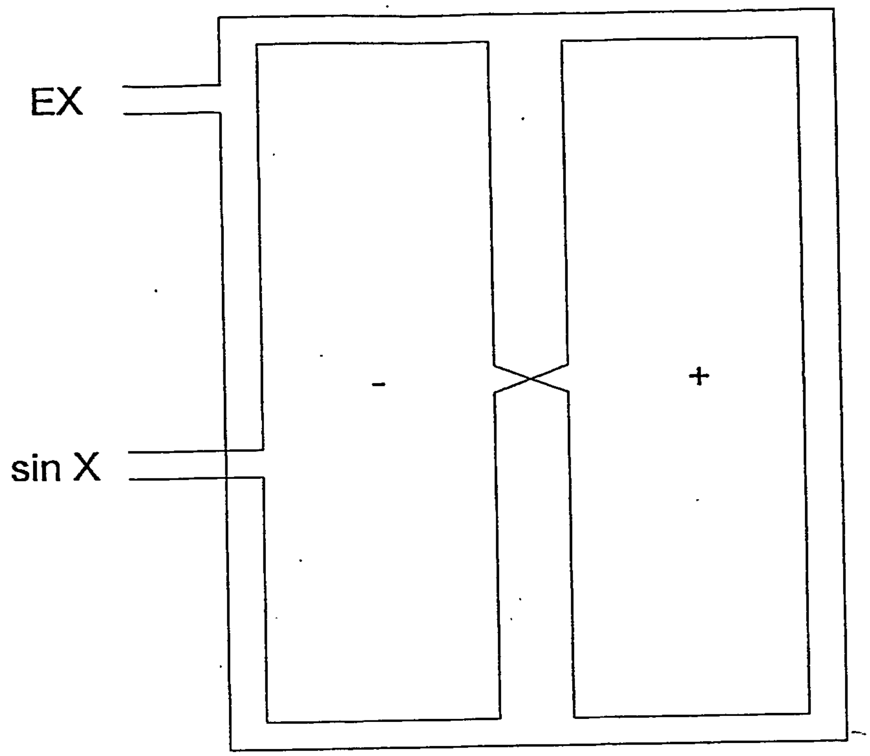

Figure 4

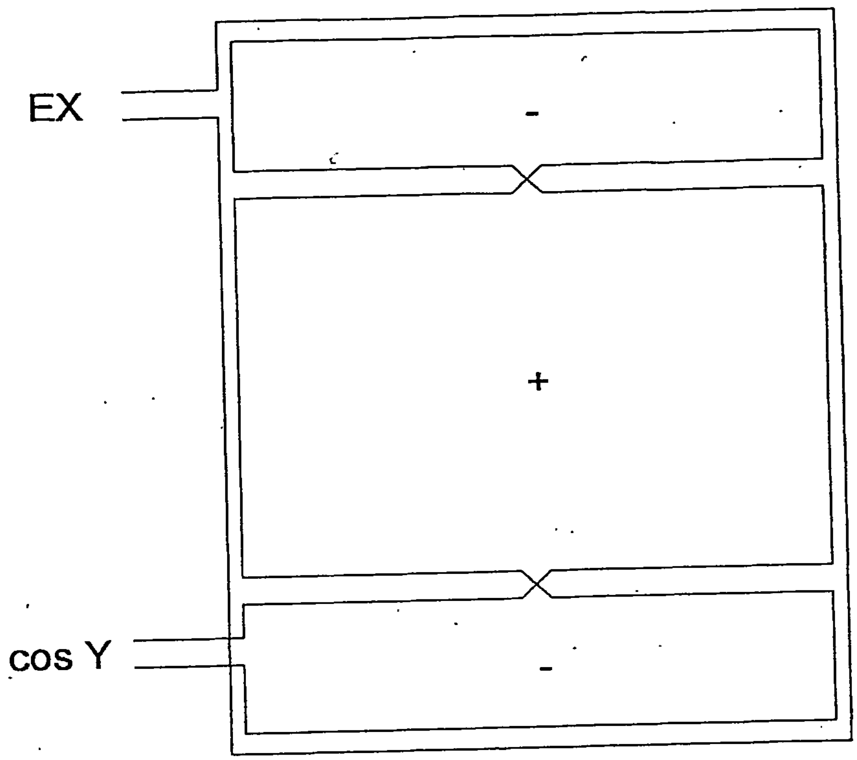

Figure 5

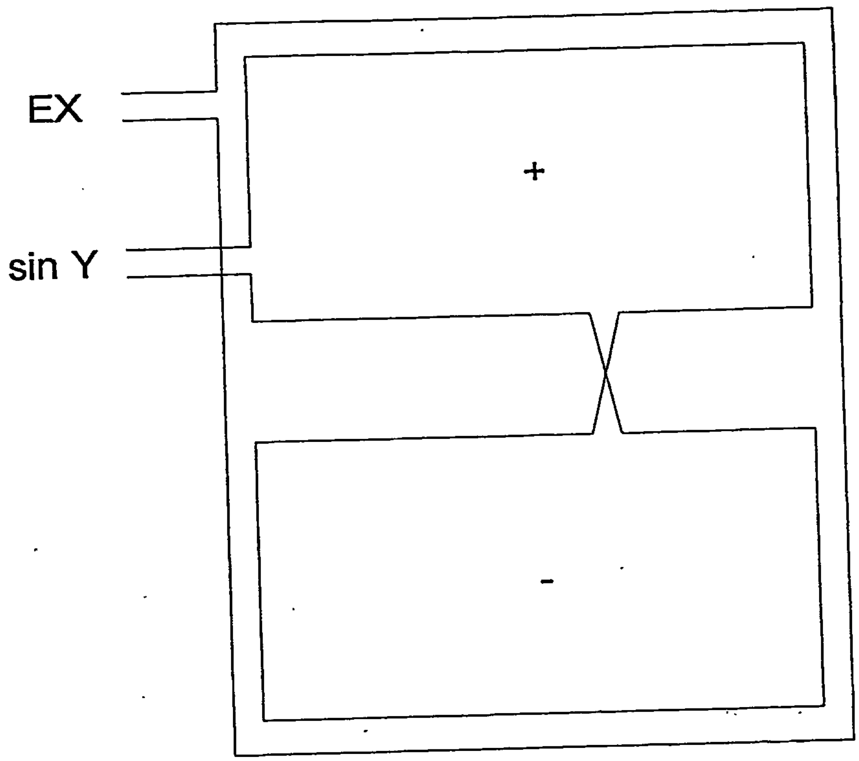

Figure 6

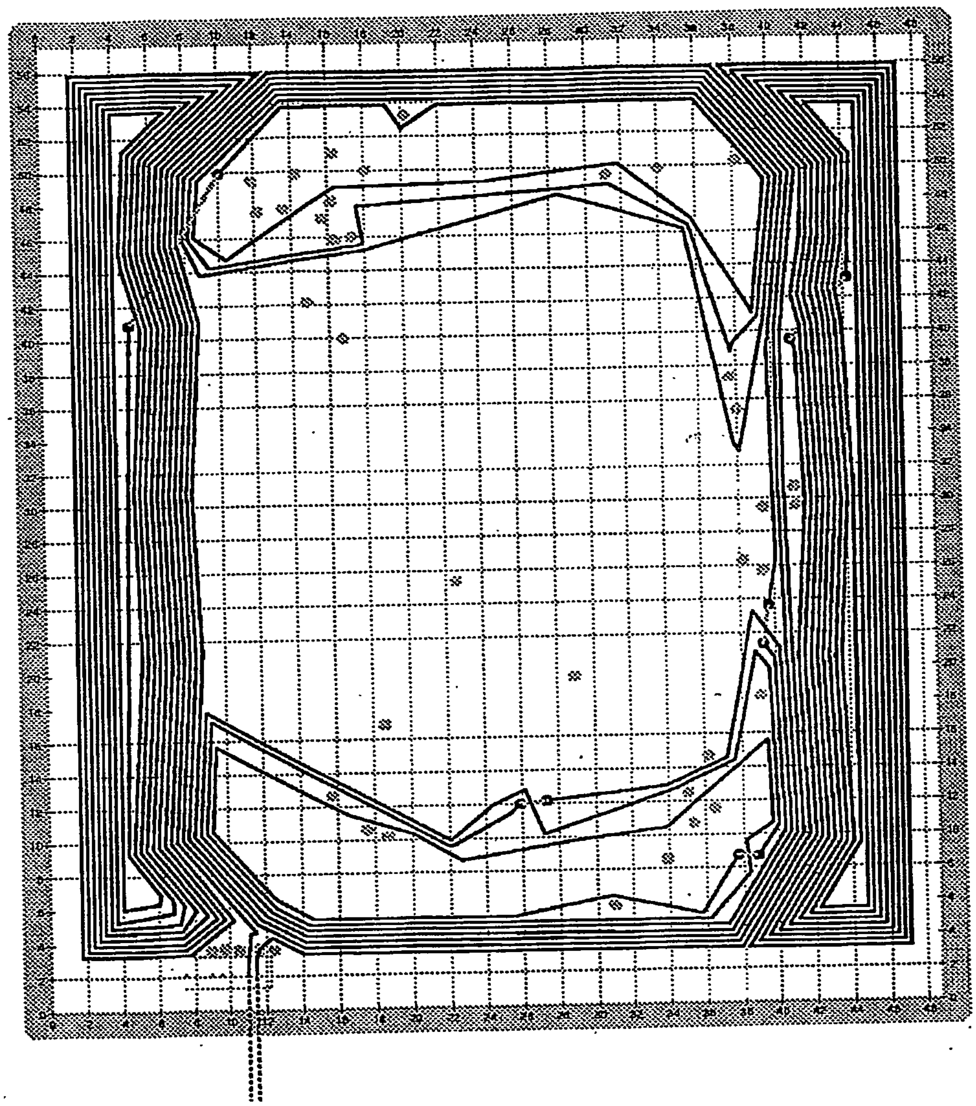

Figure 7

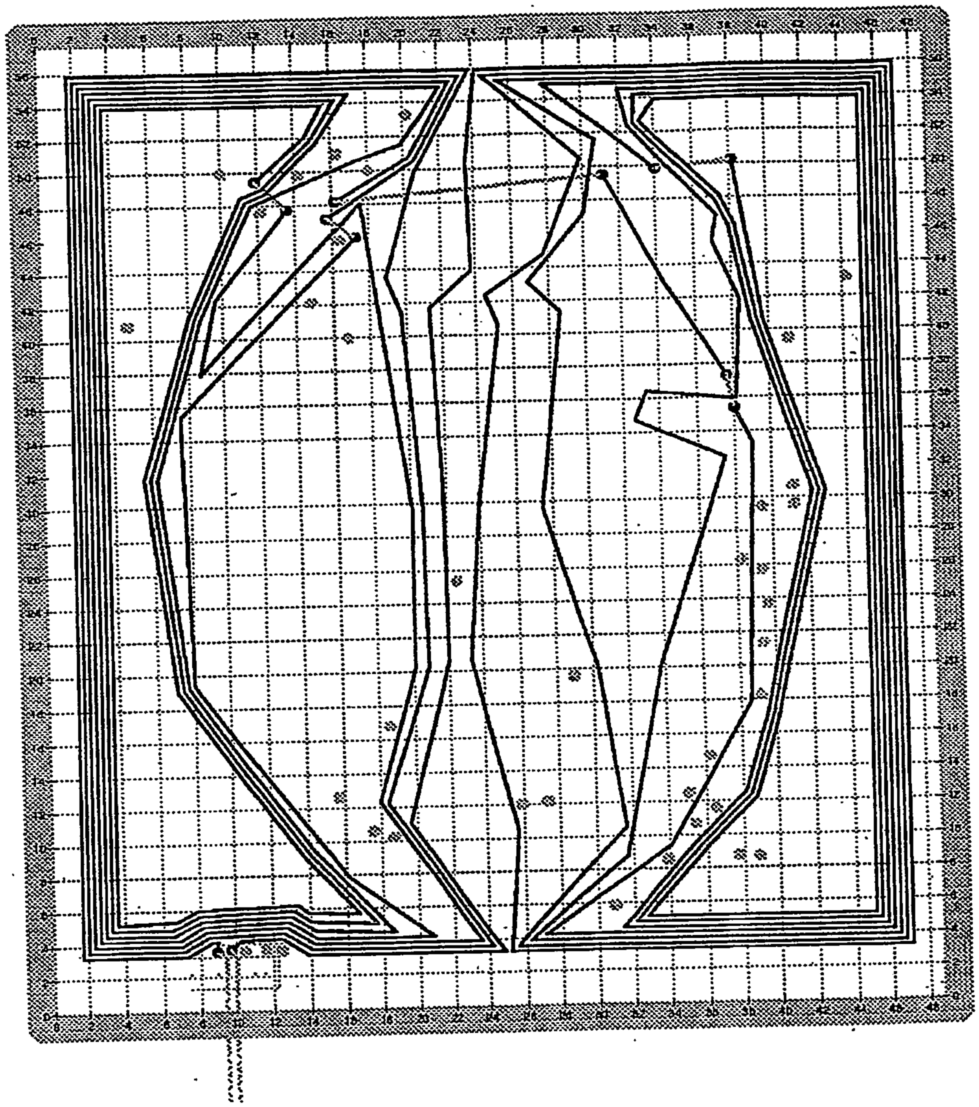

Figure 8

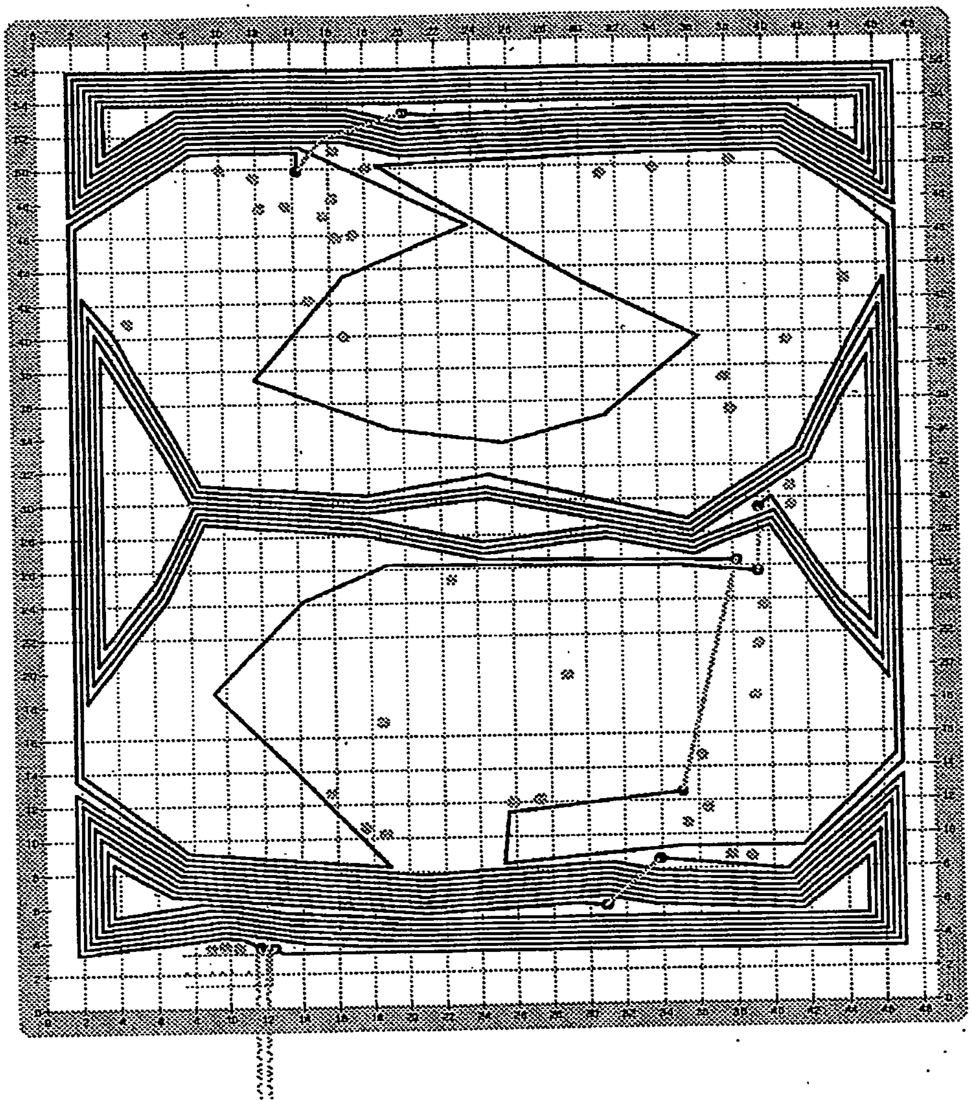

Figure 9

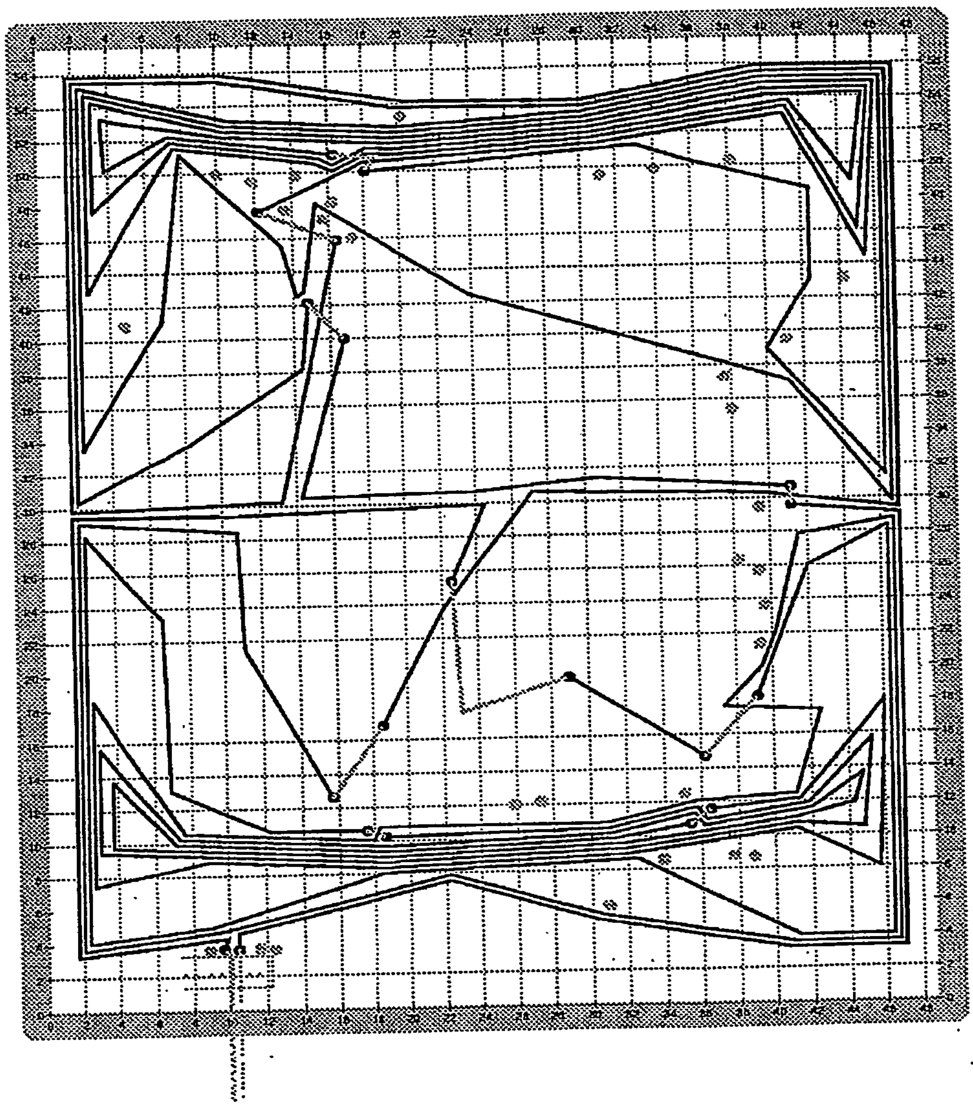

Figure 10

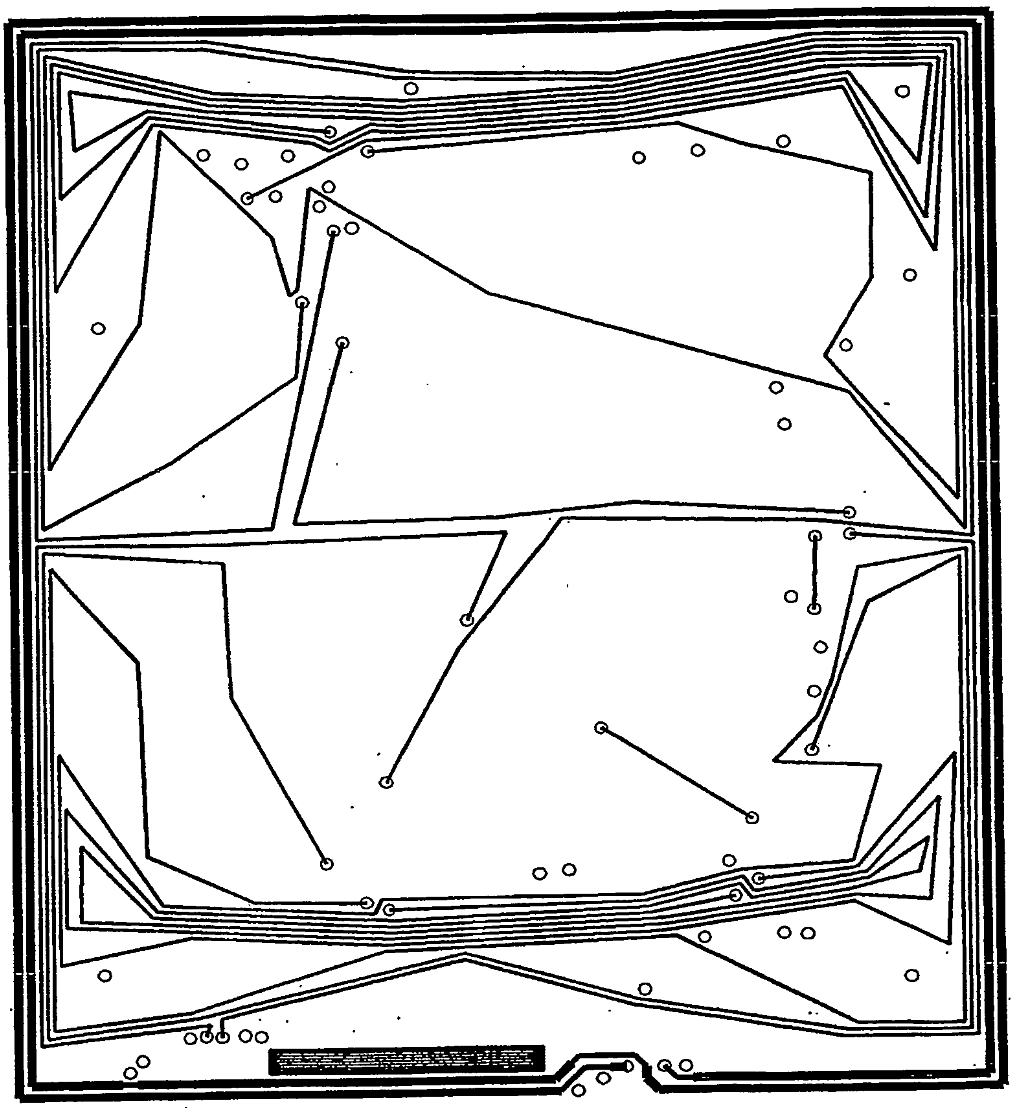

Figure 11

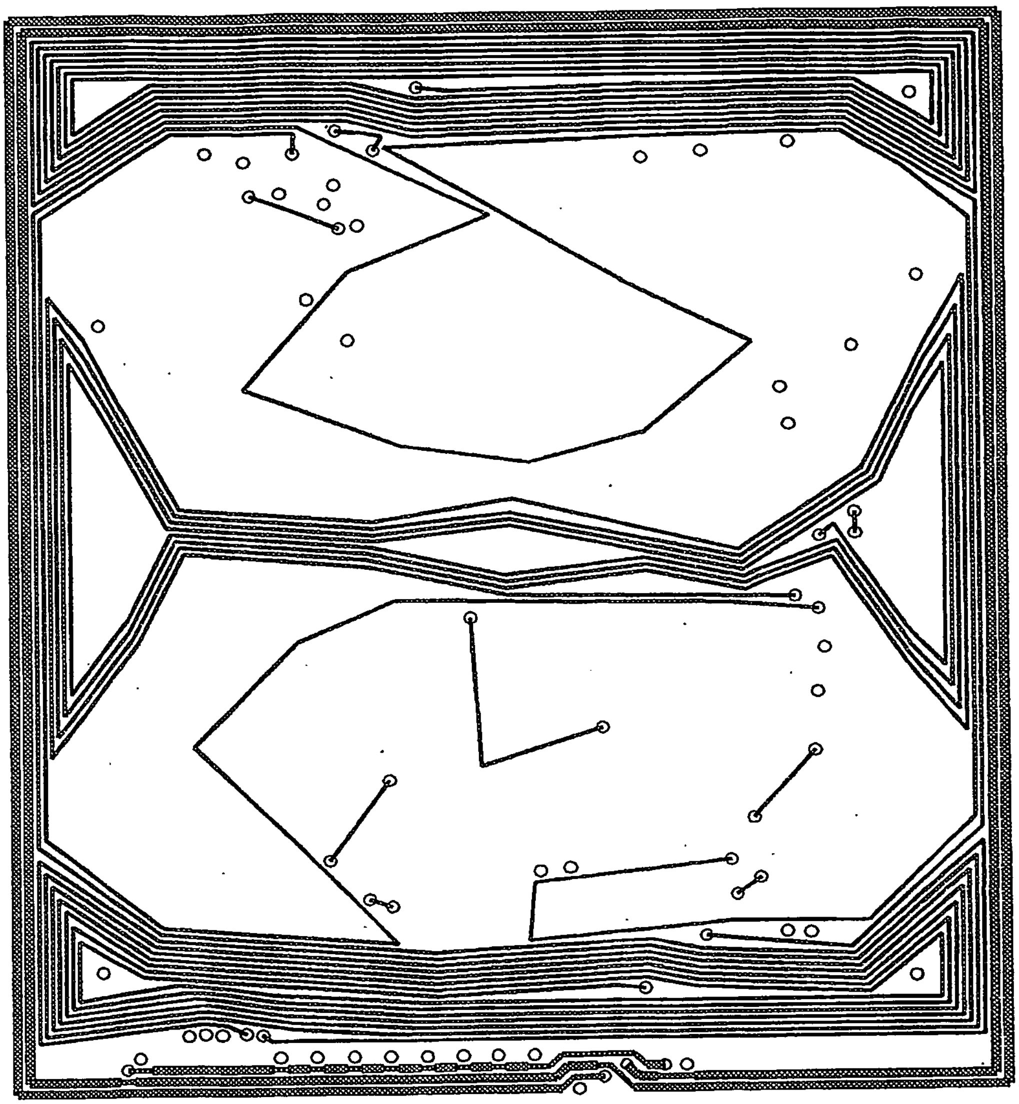

Figure 12

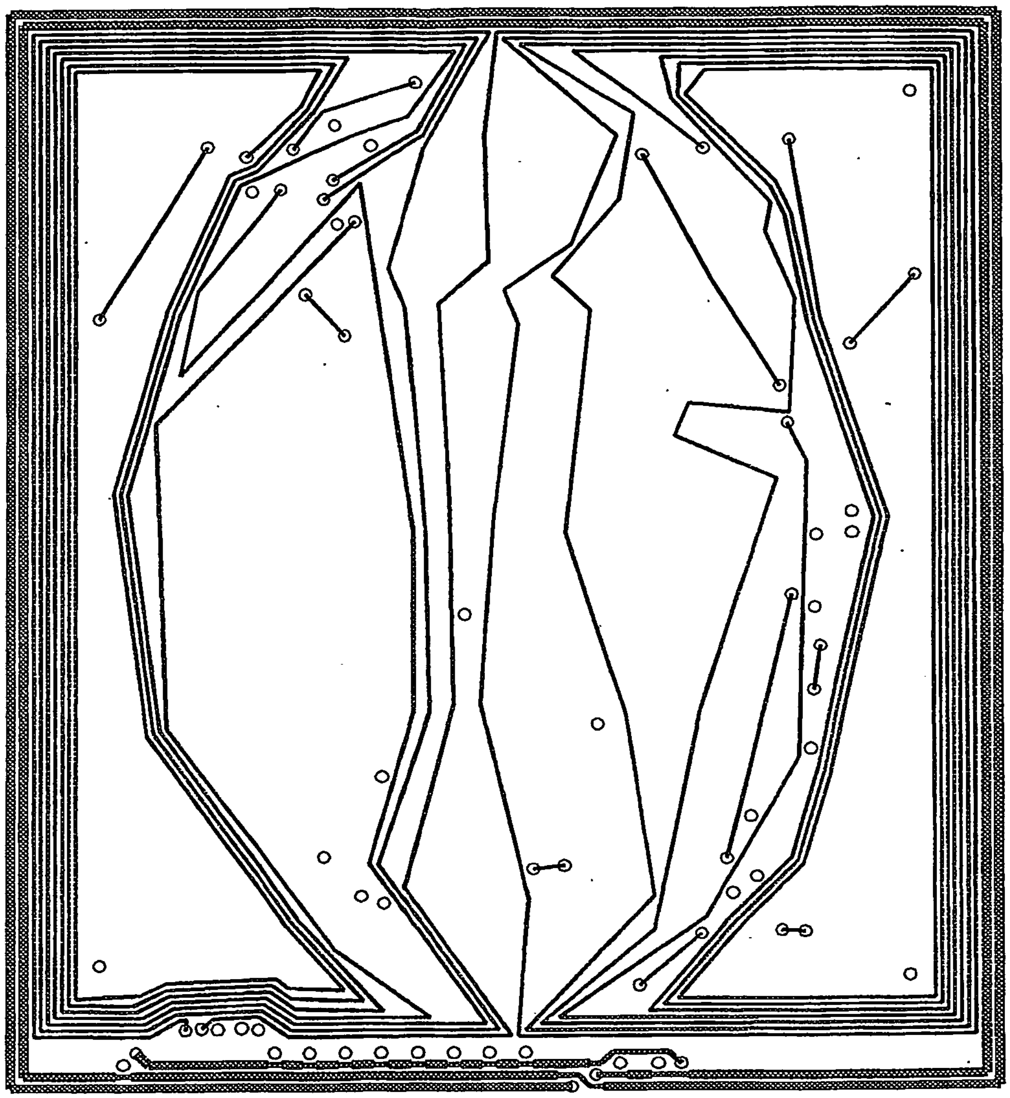

Figure 13